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A STUDY OF THE EFFECTS OF UNDERWATER EXPLOSIONS ON SHIP HULL

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Abstract: *In this paper we made an analysis of effects of underwater explosions on ship hull. The effect of the underwater explosions on ship hull is a characteristic of navy warfare. The effect could be: total damage (destruction), damage (mobility kill), light damage. The criteria used for the effects evaluation are tactically and technically and depends with ship type, overall dimensions of ship, ship missions etc. We made simulations for three explosions of a depth charge (a spherical depth charge made by TNT with 300 kilos weight) placed on various distances from ship at 20 meters depth .*

Key-words: *underwater explosion, ship hull*

1. THE FINITE ELEMENTS MODEL OF SHIP STIFFNESS STRUCTURE

In order to simplify the model, for the entire ship hull we kept only the elements which gives ship`s strength and rigidity. We took in consideration the following elements: ribs, longitudinal beams, transverse walls, bridges and shell tabs. All these elements had thin profiles and could be modeled with finite elements, bent plate type.

In figure no.1 we have a longitudinal cut-away view of ship stiffness structure. Details A and B underlined the constructive elements of the ship. We added the ship upper structure, but only for inertial consideration, because upper structure has a minor contribution on the explosion effect. In order to have the same weight of the ship, we put on the bridges additional masses (figure no.1).

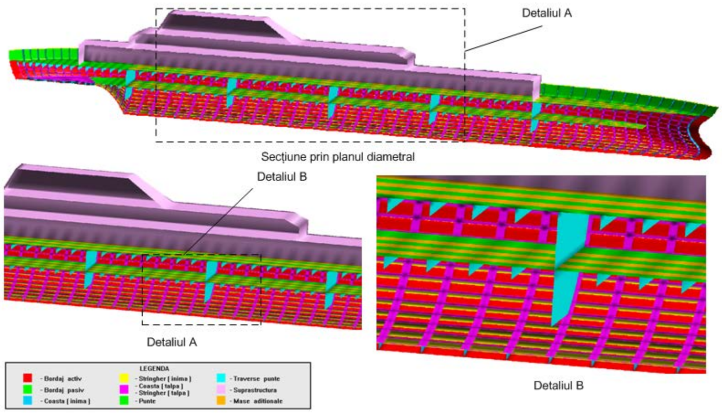

Figure no. 1. – Ship stiffness structure

2. ANALYSIS OF THE CONDITIONS

A complete model of interaction between shock waves, produced by underwater explosions and ship hull it will contain: explosion source, propagation model and ship stiffness structure. This strategy allows us to concentrate all available finite elements on ship stiffness structure, which conduct to a better discretization of ship model. The elimination of propagation environment between depth charge and ship doesn’t modify the conditions on ship borders. The effect of the shock wave on ship hull is substitute with equivalent pressure, which is time depending, and the equivalent pressure is applied on finite elements viewed from the center of explosion.

The law which give pressure in time, is depending by the time needed to shock wave to reach distance to a finite element, t_a, by time constant, θ and peak of pressure, $P_m^{'}$. The pressure in one specific point of shock wave will be :

$$p(t) = P_m e^{-t/\theta}, \tag{1}$$

Where the maximum pressure in shock wave is:

$$P_m = k\left[\frac{w^{1/3}}{R}\right]^{\alpha}, \tag{2}$$

And the time constant is given by:

$$\theta = k_\theta w^{1/3}\left[\frac{w^{1/3}}{R}\right]^{\gamma} \tag{3}$$

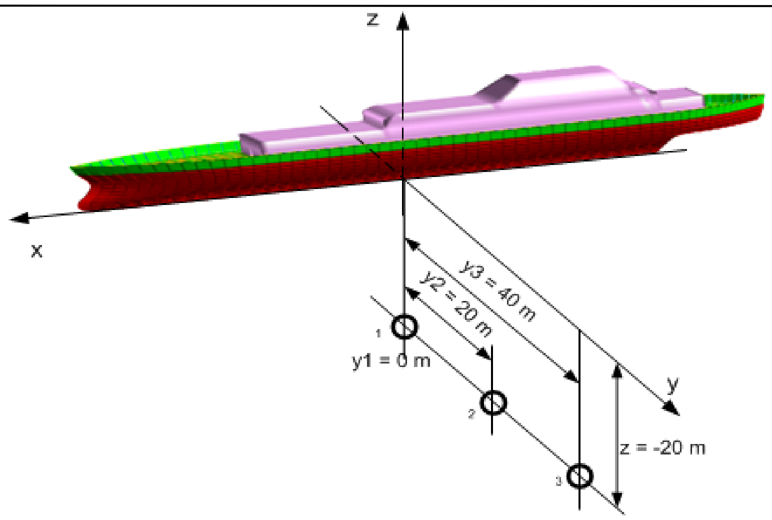

Figure no. 2 – The relative position of depth charge for the three simulations

We made three simulations, in order to study the interaction between shock waves and ship hull. We put a spherical depth charge made by TNT at 20 meters depth and modified distances from ship to charge, as you can see on figure no.2.

3. THE ANALYSIS OF THE RESULTS

The effect of the underwater explosions on ship hull is a characteristic of navy warfare. The effect could be:

- total damage (destruction),
- damage (mobility kill),
- light damage.

The criteria used for the effects evaluation are tactically and technically and depends with ship type, overall dimensions of ship, ship missions etc.

We studied the destructive effect of underwater explosions, because sea and river mines are used in defense operations to damage enemy ships. In figures no. 3 and 4 are presented the damages produced on ships. The destructive effect is bigger when the explosive charge is placed below ship.

In this particular simulation, the destructive effect of shock wave is magnified by the pulsing gas bubble, which is produced by the explosion.

In the second simulation, when the charge is placed at 20 meters depth and 20 meters lateral from ship, the damages produces are also considerable. In both cases the ship stiffness structure is badly injured, and the ship will sunk.

In the third simulation, the damages produced aren't so big, but the maneuvering capabilities of the ship are seriously affected.

In figures no. 5 and 6, we presented the distribution of von Mises equivalent tensions distributed on ship stiffness structure.

For a better representation of the equivalent tensions distribution on ship stiffness structure on the three simulations, we have frontal-lateral views from the explosive charge and below ship.

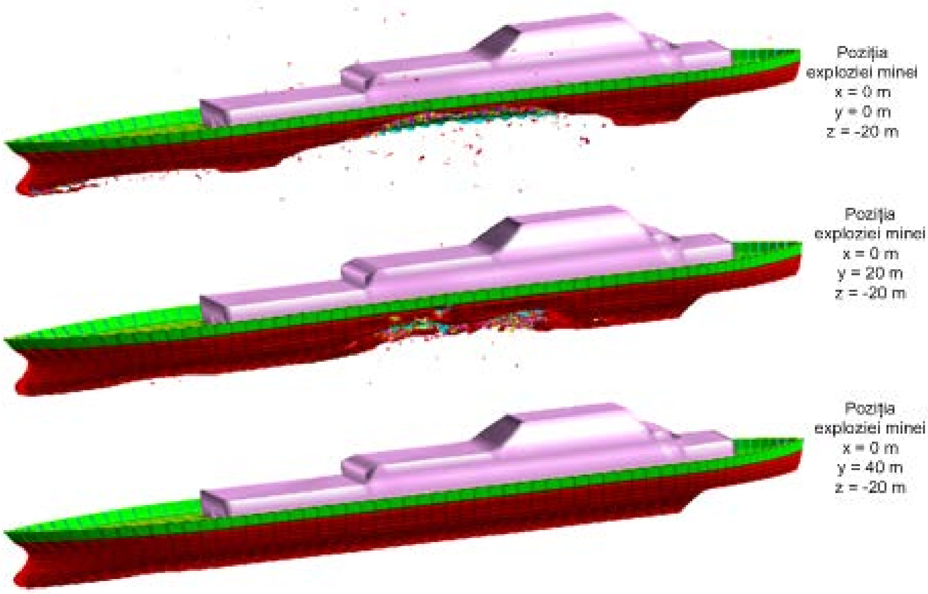

Figure no. 3. – Destuctive effect – frontal-lateral view

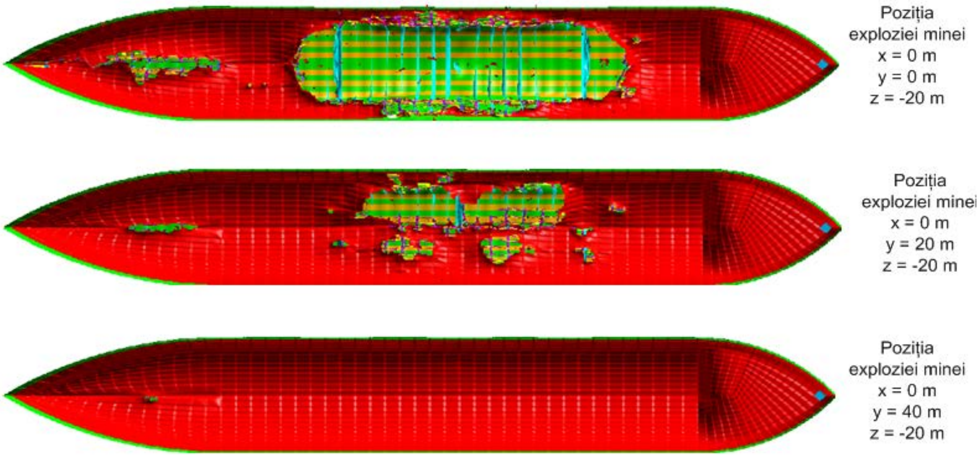

Figure no. 4. Destuctive effect – below ship view

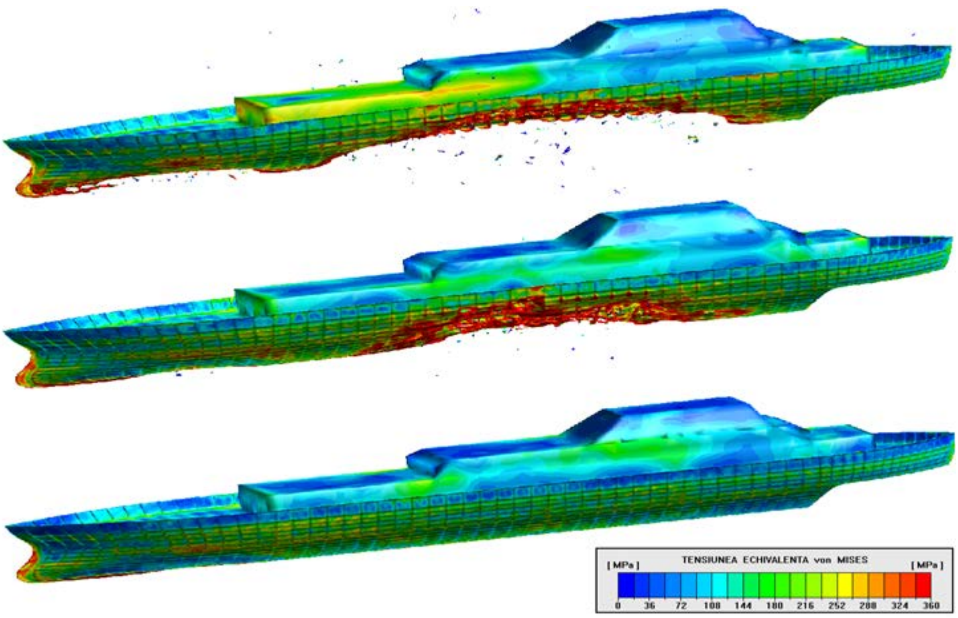

Figure no. 5. – The distribution of Von Mises tensions – frontal – lateral view

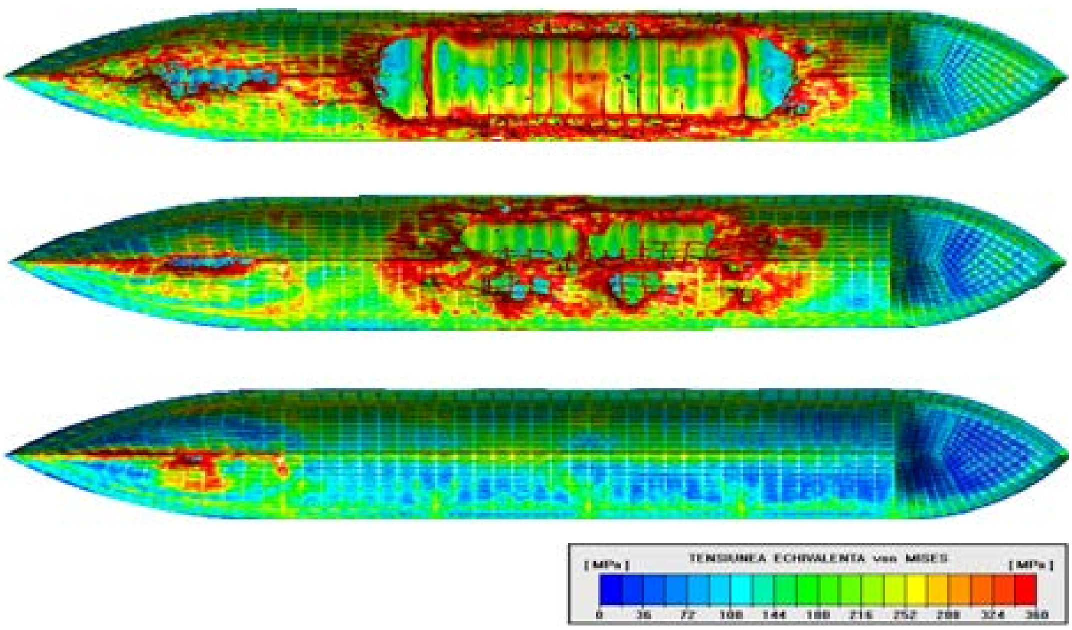

Figure no. 6. – The distribution of Von Mises tensions – below ship view

4. CONCLUSIONS

The customization of the finite element method for the fluid dynamic is necessary, because between explosive charge and ship hull is the propagation environment for the shock waves – the sea water.

The final model with finite elements was chosen after some preliminary test with reduced models. The goal of the preliminary tests was the optimization of shock waves simulation. When we made the optimization, we took care about calculus precision and time needed to solve simulations.

The conclusions drawn after preliminary test were helpfully in process of making model for the interactions between shock waves and ship stiffness structure, when underwater explosions are produced.

In our simulations we try to underline the military goals, such:

- ship sinking;
- total damage or partial damage;
- maneuvering capabilities decrees;
- making conditions to use another weapon system.

The method used for simulation, gives us good solutions, but the method need time, tens of hours, despite we used powerful computers. This methodology of simulation could be used also, to study the underwater explosion effect on: submerged harbor installations, rig platforms, bridge pillars etc.

The sea mines are one of the biggest threat for ships, and the explosion effect on ships is significant.

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